Importing Plant Stock for Wetland Restoration and Creation: Maintaining Genetic Diversity and Integrity

PURPOSE: This technical note provides background information and general guidelines for maintaining genetic diversity and integrity in wetland restoration and creation projects that use imported plant stock.

BACKGROUND: In recent times, the implications of moving plants from one location to another as part of wetland restoration and creation projects have attracted the attention of conservationists (Figure 1). Originally, concerns stemmed from a basic understanding of genetics as well as observations of differences among populations of a single species of plant. For example, heritable differences in timing of flowering and other characteristics of smooth cordgrass (*Spartina alterniflora*) collected from different locations have been known to occur since the early 1980's (Somers and Grant 1981). Later, "common garden" experiments, in which plants from different populations are grown side by side to determine if differences are driven by environmental conditions or by genetics, confirmed that concerns were justified. Furthermore, it has been known since at least 1988 that different populations of smooth cordgrass maintained characteristics of parental generations even when grown experimentally with other smooth cordgrass stock (Gallagher et al. 1988). Most recently, techniques such as RAPDs ("random amplified polymorphic DNA") and AFLP ("amplified fragment length polymorphisms") have been used to compare genetic signatures (or "DNA fingerprints"), again confirming the existence of differences among populations (Figure 2).

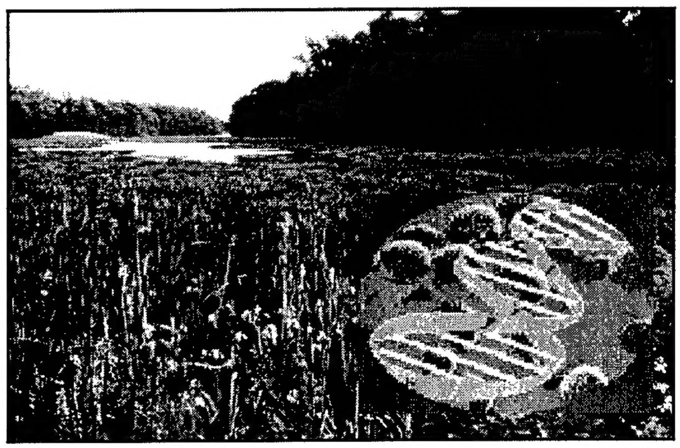
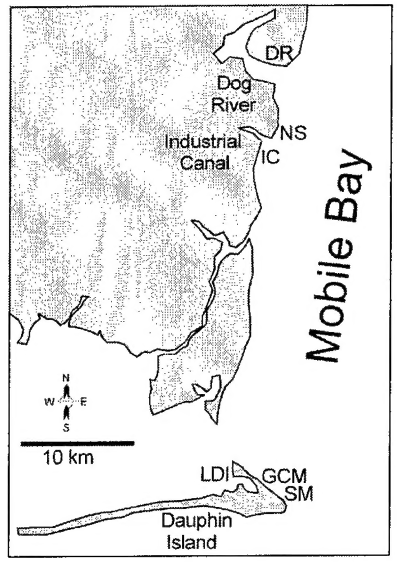


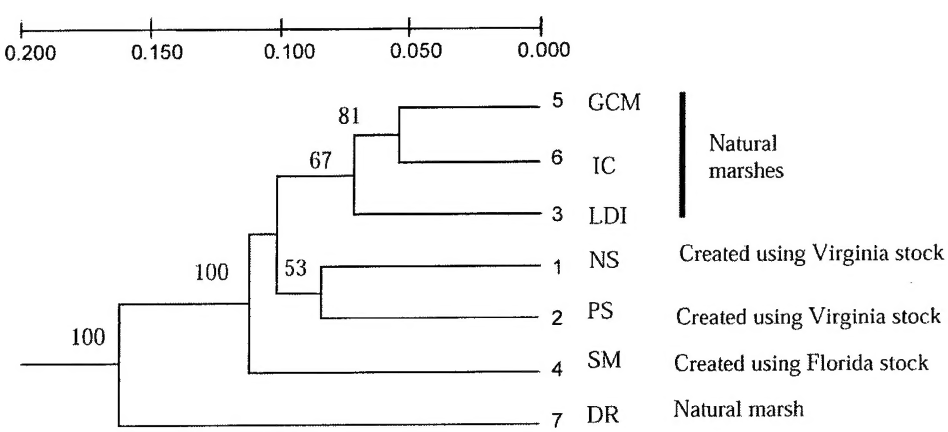
Figure 1. Conservationists are becoming concerned about the implications of moving plant stock from one location to another because of genetic differences among populations

Some U.S. Army Corps of Engineers documents have recognized the importance of plant genetics in wetland restoration and creation projects. For example, in "Compensatory Wetland Mitigation: Some Problems and Suggestions for Corrective Measures," Steve Eggers wrote "An important consideration when specifying seedings/plantings is preservation of local genotypes" (Eggers 1992). Also, some Section 404 permits calling for compensatory mitigation include requirements for plant stock obtained within a certain radius of the mitigation site in order to avoid importation of genetically distinct plants. However, these practices are not universally applied, either because potential problems with importing plant stock are not recognized or because local plant stock is not available.

Recently completed work at the U.S. Army Engineer Research and Development Center, Waterways Experiment Station, compared smooth cordgrass populations of six Mobile Bay, Alabama, salt marshes (Figure 2a) and one Maryland salt marsh. Four of the six Alabama marshes were natural marshes, while two of the Alabama marshes and the Maryland marsh were created marshes. The SM created marsh in Alabama was planted with stock imported from Florida, while the NS created marsh in Alabama and the PS created marsh in Maryland were both planted with stock imported from Quimby, Virginia. Researchers used AFLP methods and UPGMA cluster analysis to compare marshes based on genetic signatures (Figure 2b). Researchers expected genetic signatures of natural marshes in Alabama to be reasonably similar to one another and, as a group, to be distinct from the created marshes. They also expected genetic signatures from created marshes PS and NS, planted with stock from Quimby, Virginia, to be distinct from the signature of the SM marsh, planted with stock from Florida. Instead, they found that all marshes were genetically distinct, suggesting that only limited genetic exchange occurs between marshes. Three of the natural marshes were similar enough to one another to cluster into a single group, but natural marsh DR was an outlier, perhaps because it originated from seeds imported by birds or because selective factors at the DR marsh are different than those of marshes lower in the estuary. The NS and PS created marshes, both planted with stock from Quimby, Virginia, were similar enough to one another to group together, as expected. Also, all three of the created marshes were outliers relative to the natural marshes, as expected from their planting history.



a. Approximate locations of four natural marshes (DR, IC, LDI, and GCM) and two created marshes (NS and SM) in Mobile Bay, Alabama. Donor stock for the SM marsh was imported from Florida, while donor stock for the NS marsh was imported from Quimby, Virginia. Stock for the PS marsh in Maryland (not shown in the map) was also imported from Quimby, Virginia.



b. Cluster analysis showing genetic relatedness between marshes. Values at nodes represent percentage of times that similar branching topologies occurred in bootstrapping iterations. Scale bar at top represents percent differences between populations. Nodes without values occurred in fewer than 50 percent of bootstrapping iterations and should not be interpreted.

Figure 2. Application of RAPDs and AFLPs to compare genetic signatures

Despite rapid advances over the past few years, further work will be needed to link knowledge of differences based on genetic signatures to ecological differences among plants, and, ultimately, to specific guidelines about importing plant stock for wetland restoration and creation projects. Nevertheless, current knowledge provides a rationale for general guidelines. These guidelines revolve around two basic concepts: genetic diversity and genetic integrity.

Genetic Diversity. Genetic diversity can be thought of as the variability of heritable traits within a population. Populations with low genetic diversity are less likely to include individuals capable of surviving irregularly occurring environmental stress, such as drought, fire, or disease.

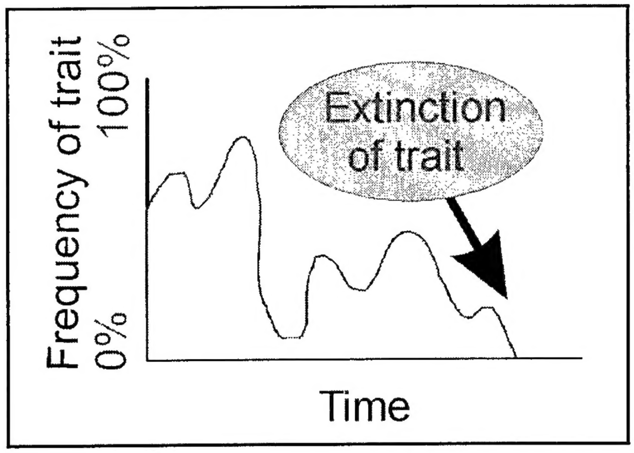


Figure 3. In small populations, genetic drift leads to reduced diversity when random fluctuations in trait frequency reach 0 percent

The most obvious cause of low genetic diversity in wetland restoration and creation projects is use of planting stock derived from a single parent plant or a small number of parent plants, such as might occur when stock is propagated vegetatively or through tissue culture. In addition, in small populations, such as those that might occur in small, isolated restoration and creation projects, genetic drift can lead to loss of heritable traits[1] and subsequent decreased diversity. In all populations, frequencies of any heritable trait vary randomly over time, but in small populations random variability may lead to disappearance of some heritable traits, eventually resulting in decreased diversity (Figure 3).

Genetic Integrity. If supporting high diversity was the only concern regarding plant genetics, it might make sense to combine stock from a number of locations in order to promote high genetic diversity. However, maintenance of genetic integrity may also be important. Just as individual plants are genetically distinct from one another, plant populations can also be distinct from one another. "Maintaining genetic integrity" simply means maintaining the unique genetic signature that characterizes a population.

Why is it important to maintain genetic integrity? One population may possess traits that are absent from another population and some of these traits may be linked to survival and growth rates under different conditions. Imported populations may not be adapted to local climate and soil conditions—that is, imported populations may not possess traits that have evolved within local populations as a response to certain environmental stresses, such as high salinity, low temperature, or fire. If local genetic integrity is maintained, traits that have evolved to adapt to local conditions will be preserved. In some cases, unexplained failure of planted sites may be related to failure to maintain genetic integrity. Furthermore, if imported stock breeds with local stock, maladaptive traits may be introduced to the local population in what has been termed "genetic pollution."

---

1 Genetic drift actually affects allele frequency, but for the purposes of this technical note allele frequency can be considered synonymous with trait frequency.

GUIDELINES ON IMPORTING PLANT STOCK: Currently available research results do not offer sufficient information on which to base specific guidelines. The general guidelines presented here are based on a combination of limited research results, theoretical knowledge of plant population genetics, and an understanding of the practicalities of planting programs in wetland restoration and creation projects.

Guidelines assume that natural recruitment has been dismissed as a viable option. In all cases, guidelines should be applied with an understanding of underlying principles and the knowledge that arbitrary decisions will have to be accepted in the absence of sufficient information. These guidelines are as follows:

- Populations of some plant species are known to have unique genetic signatures even within a single watershed or estuary, and plants with different genetic signatures are known to have different tolerances to environmental conditions (Smith and Proffitt 2000). The degree of genetic differentiation among plant populations and associated implications for survival of planted sites are unknown. **To err on the side of caution, plant stock (harvested as seed, plugs, etc.) from donor wetlands adjacent to a restoration or creation project site should be used in preference to all other plant stock sources, provided that usable plant stock can be gathered without unreasonable impacts to the donor wetlands.**
- If nearby donor wetlands are not available, stock may have to be imported from some distance away. Stock from different latitudes is likely to have a different flowering time than local stock and may be adapted to different climatic conditions (Somers and Grant 1981). **If stock must be imported, it should be imported from the nearest available source, with latitudinal distances generally representing a greater cause for concern than longitudinal distances.**
- Within a species, genetically distinct populations may occur on adjacent sites with different conditions. For example, saltmeadow cordgrass (*Spartina patens*) plants growing within 200 m of one another in salt marshes, on sand dunes, and in swales between dunes in North Carolina are genetically distinct, with genetic differences reflecting adaptive traits that apparently increase survival and growth in each of the habitat types (Silander 1979). **As a general rule, plant stock should be taken preferentially from donor wetlands with environments that are similar to the environment of the restoration or creation project site, provided that usable plant stock can be gathered without unreasonable impacts to the donor wetlands.**
- In many cases, plant stock is purchased from nurseries. **By planning ahead, nurseries can be contracted to gather, germinate, and grow stock from specified donor wetlands, so that projects are not forced to use potentially inappropriate stock.**
- Occasionally, plant stock with special characteristics is imported for restoration and creation projects. For example, the Vermilion strain of smooth cordgrass is frequently planted in Texas, where it appears to grow more quickly than local stock and to resist infections by fungus. **While use of plant stock with special characteristics may be desirable in some cases, potentially negative effects on loss of genetic integrity should not be overlooked.**
- Single clones, or genetically identical plants, result from vegetative spread, vegetative propagation, and propagation via tissue culture. Planting of an individual clone on a

restoration site can result in unnaturally low genetic diversity for the site. **Stock obtained through vegetative propagation or propagation via tissue culture should be avoided.**

POINTS OF CONTACT: For additional information, contact Dr. Bill Streever (601-634-2942, *streevw@wes.army.mil*), or the Program Manager of the Wetlands Regulatory Assistance Program, Dr. Russell F. Theriot (601-634-2733, *therior@wes.army.mil*). This technical note shoud be cited as follows:

> Streever, W., and Perkins, E. (2000). "Importing plant stock for wetland restoration and creation: Maintaining genetic diversity and integrity," *WRAP Technical Notes Collection* (ERDC TN-WRAP-00-03), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/wrap*

REFERENCES

Eggers, S. (1992). "Compensatory wetland mitigation: Some problems and suggestions for corrective measures," U.S. Army Engineer District, St. Paul.

Gallagher, J. L., Somers, G. F., Grant, D. M., and Seliskar, D. M. (1988). "Persistent differences in two forms of *Spartina alterniflora*: A common garden experiment," *Ecology* 69, 1005-1008.

Silander, J. A. (1979). "Microevolution and clone structure in *Spartina patens*," *Science* 203, 658-660.

Smith, D. L., and Proffitt, C. E. (1999). "The effects of crude oil and remediation burning on three clones of smooth cordgrass (*Spartina alterniflora* Loisel.)," *Estuaries* 22(3A), 616-623.

Somers, G. F., and Grant, D. (1981). "Influence of seed source upon phenology of flowering of *Spartina alterniflora* Loisel. and the likelihood of cross pollination," *American Journal of Botany* 68, 6-9.